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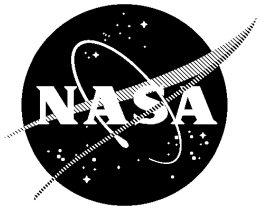
MISSION OPERATIONS AND DATA SYSTEMS DIRECTORATE

Earth Science Data and Information System (ESDIS) Level 1 Product Generation System (LPGS) Release Implementation Plan

January 1998



National Aeronautics and Space Administration

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Greenbelt, Maryland

Earth Science Data and Information System (ESDIS)
Level 1 Product Generation System (LPGS)
Release Implementation Plan

January 1998

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Preface

This document contains the software release implementation plan that defines the incremental buildup of functionality for the Earth Science Data and Information System (ESDIS) Level 1 Product Generation System (LPGS). The allocation of software to releases is based on an analysis of the requirements contained in the

- LPGS Functional and Performance Requirements Specification
- Related interface control documents (ICDs)
- LPGS System Design Specification
- LPGS Detailed Design Specification

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Abstract

This document contains the software release implementation plan that defines the incremental buildup of functionality for the Earth Science Data and Information System (ESDIS) Level 1 Product Generation System (LPGS). The allocation of software to releases is based on an analysis of the requirements contained in the LPGS Functional and Performance Requirements Specification, related interface control documents (ICDs), and the LPGS design presented in the LPGS System Design Specification and LPGS Detailed Design Specification documents. The availability of candidate software for reuse, including software from other Landsat 7 ground system elements [e.g., Landsat Processing System (LPS) and Image Assessment System (IAS)], and the sizing of new software were considered in allocating software to releases.

Keywords*: Earth Observing System Data and Information System (EOSDIS), Earth Resources Observation System (EROS), Earth Science Data and Information System (ESDIS), EDC Distributed Active Archive Center (EDC DAAC), EOSDIS Core System (ECS), EROS Data Center (EDC), Landsat 7, Level 1 Product, Level 1 Product Generation System (LPGS), Mission Operations and Data Systems Directorate (MO&DSD), Mission Operations and Systems Development Division (MOSDD), Systems Management Policy (SMP)*

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Section 1. Introduction

1.1 Purpose

The Earth Science Data and Information System (ESDIS) Level 1 Product Generation System (LPGS) Release Implementation Plan documents the system release approach that will be used by the Mission Operations and Systems Development Division (MOSDD) of the Mission Operations and Data Systems Directorate (MO&DSD) at the National Aeronautics and Space Administration's (NASA's) Goddard Space Flight Center (GSFC) in implementing the subsystems of the LPGS.

The system release approach is an incremental approach to implementing, integrating, and testing systems. As the system is developed, each successive release adds to the system functionality provided in previous releases. Release 1 of the LPGS will implement the majority of the Earth Observing System Data and Information System (EOSDIS) Core System (ECS)/LPGS interface and the automatic generation of a Level 1 product. Release 2 will complete the implementation of the ECS/LPGS interface, support trouble ticket processing, focus on the manual override options of the LPGS, add the disk maintenance functions, and support the IAS/LPGS interface. Release 2 will implement the remainder of the requirements detailed in the baselined version of the LPGS Functional and Performance Requirements Specification (Reference 1), the ECS/Landsat 7 interface control document (ICD) (Reference 2), the Image Assessment System (IAS)/LPGS ICD (Reference 3), and the ECS/LPGS ICD (Reference 4), applicable to the LPGS.

This plan describes the system release approach that will be used to implement the LPGS. This plan provides a detailed definition of the requirements and functions allocated to each release, and it maps software modules to each release. It also presents the release implementation schedule necessary to support Landsat 7.

1.2 Applicable Documents

The following documents contain background and/or detailed information that was referenced in creating the LPGS Release Implementation Plan.

1. National Aeronautics and Space Administration (NASA), Goddard Space Flight Center (GSFC), 510-FPD/0196, *Earth Science Data and Information System (ESDIS) Level 1 Product Generation System (LPGS) Functional and Performance Requirements Specification*, Revision 1, to be published January 1998

2. Hughes Information Technology Systems, 505-41-32, *Interface Control Document Between EOSDIS Core System (ECS) and the Landsat 7 System*, Revision A, May 1997

3. NASA, GSFC, 514-4ICD/0197 (CSC 10037996), *Interface Control Document Between the Image Assessment System (IAS) and the Level 1 Product Generation System (LPGS)*, Review, January 1998

4. Hughes Information Technology Systems, 423-41-55, *Interface Control Document Between the EOSDIS Core System (ECS) and the Level 1 Product Generation System*, October 1997

5. NASA, GSFC, 510-4DDS/0197 (CSC 10038085), *Earth Science Data and Information System (ESDIS) Level 1 Product Generation System (LPGS) Detailed Design Specification (DDS)*, Review, January 1998

6. —, *Earth Science Data and Information System (ESDIS) Level 1 Product Generation (LPGS) Integration and Test Plan*, August 1997

7. —, 505-10-23, *ESDIS Security Policy and Guidelines*, March 1996

8. —, NHB2410-9A, *NASA Automated Information Security Handbook*, June 1993

9. —, 510-1IDD/0197 (CSC 10037648), *Earth Science Data and Information System (ESDIS) Level 1 Product Generation System (LPGS) Interface Definitions Document (IDD)*, November 1997

10. —, 514-3IP/0197 (CSC 10037828), *Landsat 7 Image Assessment System (IAS) Release Implementation Plan*, July 1997

11. —, 510-4SDS/0196 (CSC 10034686), *Earth Science Data and Information System (ESDIS) Level 1 Product Generation System (LPGS) System Design Specification*, March 1997

12. —, 510-3DFC/0197 (CSC 10036361), *Earth Science Data and Information System (ESDIS) Level 1 Product Generation System (LPGS) Output Files Data Format Control Book*, Signoff Version, November 1997

Section 2. System Overview

2.1 LPGS Objectives

The LPGS is an element of the Earth Observing System (EOS) Ground System (EGS). The LPGS interfaces with the Land Satellite 7 (Landsat 7) System and other EGS elements.

The following are the primary objectives of the LPGS:

- To produce radiometrically and systematic geometrically corrected digital images of data collected by the Landsat 7 Enhanced Thematic Mapper Plus (ETM+)
- To provide radiometric characterization data to the Landsat 7 IAS

To meet these objectives, the LPGS must perform the following functions:

- Interface with the ECS to receive Level 1 product generation requests submitted to the ECS by the user community
- Obtain from the ECS the necessary Level 0R ETM+ data and ancillary files necessary to fulfill the product generation request
- Produce a consensus payload correction data (PCD) file and a mirror scan correction data (MSCD) file
- Apply the appropriate radiometric and geometric correction algorithms
- Transfer to the ECS the requested Level 1 image in the user-requested format, along with the appropriate calibration parameter file (CPF), consensus PCD and MSCD files, and updated metadata file
- Capture and store, for periodic transfer to the IAS, the characterization data generated by the radiometric processing algorithms

2.2 LPGS Subsystem Descriptions

The LPGS capabilities are partitioned into seven subsystems. The following paragraphs describe the purpose and basic functionality of each subsystem. Two of these subsystems are black boxes in that the software is developed independently of the LPGS, for use by the LPGS and the Landsat 7 IAS. These black boxes are the Radiometric Processing Subsystem (RPS) and the Geometric Processing Subsystem (GPS). A more detailed description of each LPGS subsystem can be found in the LPGS Detailed Design Specification (Reference 5). Underlying these subsystems and supporting their functionality and interprocess communication is an Oracle database.

Process Control Subsystem

With only a few exceptions, the Process Control Subsystem (PCS) coordinates all processing within the LPGS. It provides automated control of product request scheduling and processing. By default, PCS maintains first-in first-out (FIFO) processing of product generation requests. It also provides a manual capability for viewing and adjusting the LPGS production schedule.

PCS converts product generation requests into work orders. As needed, it automatically initiates, coordinates, and monitors work order processing. Additionally, PCS supports manual operations including visual quality assessment during generation of the Level 1 product.

Data Management Subsystem

The Data Management Subsystem (DMS) supports data formatting and external systems interfaces. The primary products formatted by DMS are the Level 1 product (Reference 12) [in Hierarchical Data Format (HDF), Georeference Tag(ged) Image File Format (GeoTIFF), or FAST-L7 format] and the consensus PCD and MSCD files. DMS controls the LPGS electronic interfaces with the IAS and the ECS. The LPGS provides characterization statistics to the IAS to support IAS's calibration efforts. DMS receives product requests and L0R files from the ECS. For each successfully processed product request, DMS provides the properly formatted Level 1 image and additional supporting data to the ECS. It is also responsible for automatically deleting files after they have been successfully transferred to the ECS.

Radiometric Processing Subsystem

The Radiometric Processing Subsystem (RPS) provides all functionality required for Level 1R product generation, radiometric calibration, and radiometric characterization and evaluation. This subsystem implements all of the LPGS radiometry algorithms.

Geometric Processing Subsystem

The Geometric Processing Subsystem (GPS) provides all functionality required for Level 1G product generation, geometric calibration, and geometric characterization and evaluation. This subsystem implements all of the LPGS geometry algorithms.

Quality Assessment Subsystem

The Quality Assessment Subsystem (QAS) performs automatic quality assessment of Level 1R and Level 1G images. Using a combination of Level 1R thresholds and characterizations, QAS conducts the Level 1R quality assessment immediately following completion of radiometric processing. Similarly, using Level 1G thresholds, the Level 1G assessment is done immediately following completion of geometric processing. QAS also provides the option for a manual visual quality assessment of a Level 1R or Level 1G image. Additionally, QAS supports the visual quality assessment of the Level 1 product after it has been placed in its final HDF, GeoTIFF, or FAST-L7 format.

Anomaly Analysis Subsystem

The Anomaly Analysis Subsystem (AAS) provides the tools required by the LPGS analyst to resolve internal LPGS anomalies, resulting from processing failures, and trouble tickets assigned to the LPGS by the ECS. AAS supports the LPGS analyst by providing benchmark tools for confirming the integrity of the LPGS configuration. Additionally, AAS provides utilities to view all input received from the ECS, as well as to review radiometric and geometric processing inputs, intermediate products, and results. Through AAS, the analyst is provided with the tools to display Level 0R, Level 1, and intermediate images. AAS maintains an anomaly status table and generates anomaly reports.

User Interface

The user interface (UI) is designed to support the job requirements of LPGS operations personnel. In the case of the LPGS, this means that two distinct types of user interfaces are provided—one for the LPGS operator functions and another for the LPGS analyst functions. The operator user interface (OUI) is provided through Oracle Forms. The analyst user interface (AUI) is provided through Oracle Forms and a commercial off-the-shelf (COTS) package, Environment for Visualizing Images (ENVI), for viewing images. Both interfaces allow the user to select functions to be performed.

2.3 LPGS Implementation Responsibilities

The LPGS "infrastructure" subsystems—PCS, DMS, QAS, AAS, and UI—are being developed by CSC and Code 551 personnel in support of GSFC Code 514. RPS is being developed by the Algorithm Implementation Team (AIT), an integrated product team of personnel from GSFC, CSC, Century Computing, MindBank, and SGT, Inc. GPS is being developed by the IAS Project at the Earth Resources Observation System (EROS) Data Center (EDC) in Sioux Falls, SD.

Section 3. Release Plan

3.1 LPGS Release Capability Summary

The LPGS will be implemented in two releases. Release 1 of the LPGS will implement the automatic generation of a Level 1 product and the majority of the ECS/LPGS interface functionality (i.e., everything except electronic transmission of the completed L1 product from the LPGS to the ECS). Release 2 will focus on the operator override options of the LPGS, trouble ticket handling, the disk maintenance functions, the remaining portion of the ECS/LPGS interface, and the IAS/LPGS interface. The functions developed in each release are summarized in Table 3-1. Appendix A maps LPGS system requirements to the releases. Appendix B lists the lines of code (LOC) estimates for each release. Appendix C maps the modules to each release.

Release 1 provides the capabilities to produce a Level 1 product. The LPGS capabilities implemented in Release 1 include functions for ingesting data from the ECS, conversion of product requests to work orders, automatic scheduling of work order processing, invocation of radiometric and geometric processing, automatic quality assessment, and a minimal operator/analyst user interface. For anomaly investigation, tools will be provided to look at basic anomaly analysis information such as file contents.

Release 1 of the LPGS focuses on requirement 3.1.11 (unattended operations, i.e., no human intervention in the generation of the Level 1 product). Therefore, minimal user interface screens will be developed in Release 1 of the LPGS. Release 2 will put the full complement of user interface screens into place.

Release 2 completes the functionality of the LPGS. The LPGS is expanded to include the full complement of process control, data management, quality assessment, and user interface capabilities, as well as anomaly analysis tools. Level 0R and Level 1 image display will be provided through the use of ENVI in Release 2. The LPGS interface with the IAS, as well as any interactions with the ECS trouble ticket system, is implemented in Release 2. Additionally, Release 2 provides the operator override capabilities and other non-nominal functions. When Release 2 is completed, the LPGS will be able to generate, on average, 100 Level 1 scene equivalents every 24 hours.

3.2 LPGS Release Schedule

Table 3-2 is the LPGS schedule from the beginning of Release 1 implementation through LPGS site installation in the EDC Distributed Active Archive Center (DAAC).

3.3 Resources Required

This section describes the system hardware, allocation of major COTS software, and test resources for the LPGS implementation.

Table 3-1. Function Allocation to Releases

Subsystem	Release 1	Release 2
Process control	Start up and shut down LPGS	Support manual overrides
	Automatically schedule work order	Support non-nominal processing
	Automatically process work order	Generate LPGS processing statistics
Data management	Ingest Level 0R products from ECS	Manage disk space
	Quality assess Level 0R products; generate consensus PCD and MSCD	Interface with IAS
	Generate Level 1 product in HDF and GeoTIFF formats	Add HDF directory file to Level 1 HDF product Generate Level 1 product in FAST-L7 format Provide Level 1 products to ECS Record ECS interface statistics
Quality assessment	Automatic quality assessment of image immediately following radiometric and geometric processing	Visually assess image immediately following radiometric and geometric processing Visually assess formatted, Level 1 product
Anomaly analysis	Provide tools for examining contents of input, intermediate, and output test files	Perform anomaly analysis of trouble tickets Run benchmarks Run diagnostic work orders Provide tools for viewing images
User interface	Provide partial operator and analyst interface	Provide operator and analyst interface
Radiometric processing	Detect Level 0R image artifacts (striping, banding, scan correlated shift, dropped scan lines)	
	Characterize Level 0R image (striping, banding, dropped scan lines)	
	Correct Level 0R image (striping, banding, coherent noise, memory effect, scan correlated shift, inoperable detectors, dropped scan lines)	
	Generate Level 1R image (apply radiometric correction)	
Geometric processing	Generate Level 1G image (create and initialize model, generate systematic grid, resample and create systematic image)	

Table 3-2. LPGS Implementation Schedule

Planned Start	Planned Finish	Description
08/19/97	04/20/98	Release 1
08/19/97	01/26/98	Release 1 Implementation
01/26/98	03/09/98	Release 1 System Integration
03/09/98	04/20/98	Release 1 System Test
	04/20/98	Release 1 Completed
01/26/98	09/21/98	Release 2
01/26/98	06/22/98	Release 2 Implementation
06/22/98	08/03/98	Release 2 System Integration
08/03/98	09/21/98	Release 2 System/Factory Acceptance Test
	09/21/98	Release 2 Completed
09/21/98	10/21/98	EDC Site Installation
10/21/98	TBD	EDC Site Acceptance Test

NOTE: System testing and factory acceptance testing occur simultaneously for Release 2.

3.3.1 LPGS System Hardware

Figure 3-1 shows the LPGS development environment, including elements resident at GSFC and CSC's GreenTec IV facility.

Elements lpgs001 and lpgs002 are SGI Origin 2000s, and lpgs003 is an SGI Origin 200. Element 1pgs001 has 4 processors and 6 gigabytes (GB) of memory, element 1pgs002 has 4 processors and 3 GB of memory, and element lpgs003 has 4 processors and 256 kilobytes (kB) of memory. Elements lpgs001 and lpgs002 are located at GSFC Building 23, and element lpgs003 is located at the CSC GreenTec IV facility. They are allocated for software development and for system test throughout the development and system testing process.

LPGS analyst workstations (lpgswork1, lpgswork2, and lpgswork3) are SGI O2 workstations that will be used operationally for image evaluation and analysis. Two of these workstations, lpgswork1 and lpgswork2, are located at GSFC Building 23, and the third, lpgswork3, is located at the CSC GreenTec IV facility. These systems are available for software development through the entire development process. One of the two Building 23 workstations will be allocated for system test following the delivery of Release 1 from the Development Team to the System Test Team. In addition, there are 3 NCD X terminals located at the CSC GreenTec IV facility used in a shared development environment.

The LPGS hardware is accessible to the implementation and test teams, 24 hours a day, 7 days a week. Access on evenings and weekends is provided by keycards. Development terminals, printers, and network connections are available to the LPGS team members at the CSC GreenTec IV facility and at GSFC.

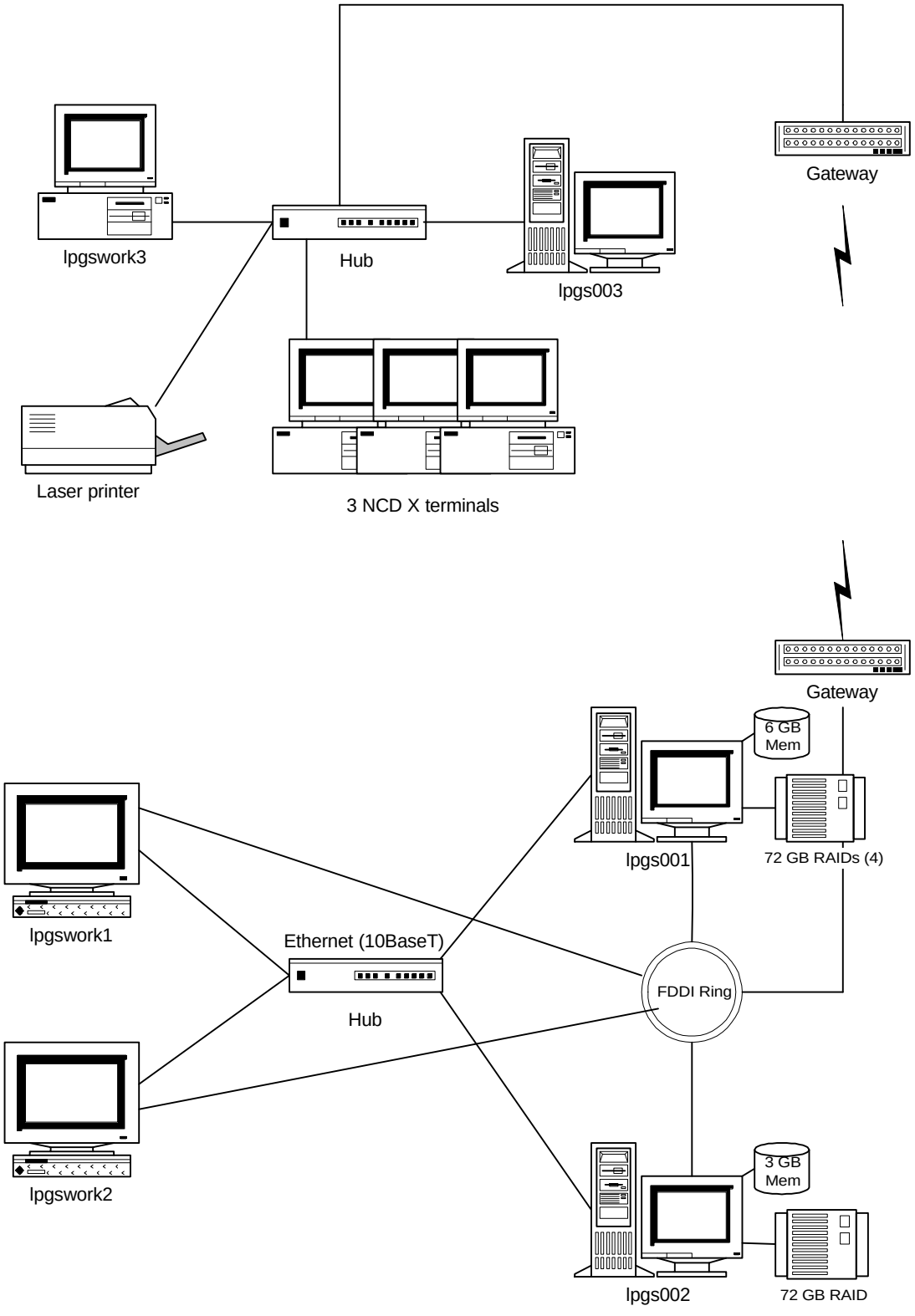

Figure 3-1. LPGS Development Environment

3.3.2 Commercial Off-the-Shelf Software

Several COTS products will be procured to support software development or to provide LPGS system functionality. Table 3-3 allocates COTS licenses across the development computers. The table includes only COTS products procured by GSFC or CSC; it does not include COTS products procured by EDC or Hughes/STX (H/STX).

3.3.3 Test Tools and Data

Raw wideband data will be obtained by reusing test data used by the IAS.

Tools to dump data from shared memory and to produce formatted dumps of LPGS files will also be borrowed from the IAS and the Landsat Processing System (LPS) Project.

Tools and data should be available for Release 1 testing. Both will be used for unit, module, subsystem, and system test, and may be provided to the customer for acceptance and operational test use.

Test tools and data are addressed in more detail in the LPGS Integration and Test Plan (Reference 6).

Table 3-3. COTS License Allocation

Table 3-3. COTS License Allocation

Product	Vendor	Total Copies	lpgs 001	lpgs 002	lpgs 003	lpgs work1	lpgs work2	lpgs work3
Analysis/Design								
Designer 2000	Oracle	1 (Note 1)						
Teamwork Ver 6.2	Cadre	35 (Note 2)						
Software Development								
Developer 2000	Oracle	(Note 3)						
Oracle Server	Oracle	(Note 3)						
SQL*Plus	Oracle	(Note 3)						
Pro*C Dev	Oracle	(Note 3)						
SQL*Net Client	Oracle	(Note 3)						
IDL Ver 5.0	RSI	2					1	1
Purify Ver 4.0	Pure Atria	3	1	1	1			
CM Tools								
RPS		Shareware						
PVCS Ver 5.2	Intersolv	(Note 4)						
Other Applications								
ENVI	RSI	3				1	1	1
HDF Library	NCSA	Shareware						
EgFTP	H/STX	Shareware						
ODL Parser	University of Colorado	Shareware						

Note 1: Resides on a PC.
Note 2: Shared with Landsat 7 projects; exists on IPDcase.
Note 3: All Oracle software is covered under the Landsat 7 site license.
Note 4: Covered by a CNMOS site license.

Appendix A. Mapping of Requirements to Releases

The following table maps the requirements specified in the LPGS Functional and Performance Requirements Specification to the releases in which the requirements are satisfied (i.e., fully testable). Some requirements are not allocated to software and therefore are not mapped to software requirements.

Requirement Number	Requirement Description	Release 1	Release 2
3.1	System-Level Requirements		
3.1.1	The LPGS shall nominally generate Level 1 digital images on a first ordered, first processed (FIFO) basis.	X	
3.1.2	The LPGS shall provide the capability to move a Level 1 image processing work order within the FIFO queues according to operator direction.		X
3.1.3	Deleted		
3.1.4	Deleted		
3.1.5	The LPGS shall provide the capability to generate and report LPGS error messages.		X
3.1.6	The LPGS shall provide an interactive capability to facilitate detection and correction of abnormal system conditions.	X	
3.1.7	The LPGS shall provide the capability to isolate system faults.		X
3.1.8	The LPGS shall provide the capability to recover from system faults.		X
3.1.9	The LPGS shall provide the capability to test LPGS functions and external interfaces.		X
3.1.10	The LPGS shall provide the capability to support attended operations 24 hours per day, 7 days per week, on a continuous basis.		X
3.1.11	The LPGS shall provide the capability to support unattended, automatic processing 16 hours per day, 7 days per week, on a continuous basis.		X
3.1.12	The LPGS shall provide the capability to support Landsat 7 operations for a minimum mission life of 5 years.		X
3.1.13	The LPGS shall provide the capability to execute diagnostic tests for verifying proper operation of system capabilities and components.		X
3.1.14	The LPGS shall provide the capability to support end-to-end testing of Level 1 processing functions.		X
3.1.15	The LPGS shall provide the capability to control LPGS operations.		X
3.1.16	The LPGS shall provide the capability to monitor LPGS operations.		X

Requirement Number	Requirement Description	Release 1	Release 2
3.1.17	The LPGS shall provide the capability to reconfigure LPGS system resources.		X
3.1.18	The LPGS shall provide the capability to support software upgrades while supporting normal operations.		X
3.1.19	The LPGS shall be capable of making all software and databases used in operations accessible to ECS for archiving.		X
3.1.20	The LPGS design shall be scaleable to allow for future growth in processing capability.		X
3.1.21	The LPGS shall be able to generate Level 1 digital images corresponding to either heritage Worldwide Reference System (WRS) scenes or to a partial ETM+ subinterval up to an area equivalent to three WRS scenes.	X	
3.1.22	The LPGS shall be capable of recovering from failures and aborts in a controlled manner.		X
3.2	External Interface Requirements		
3.2.1	The LPGS shall interface with the ECS to receive:		
3.2.1.1	L0R files (includes associated PCD, MSCD, and CPF)	X	
3.2.1.2	Level 1 image processing requests	X	
3.2.1.3	Data availability notification	X	
3.2.1.4	Requirement deleted by CCR LPGS970001		
3.2.1.5	Requirement deleted by CCR LPGS970002		
3.2.1.6	Product problem report (trouble ticket)		X
3.2.2	The LPGS shall interface with the ECS to coordinate the transfer of the following:		
3.2.2.1	LPGS L1 digital images		X
3.2.2.2	Requirement deleted by CCR LPGS970003		
3.2.2.3	Production quality and accounting information **NOTE**: This requirement to be deleted		
3.2.2.4	Requirement deleted by CCR LPGS970005		
3.2.2.5	L1 metadata		X
3.2.2.6	PCD file (consensus)		X
3.2.2.7	MSCD file (consensus)		X
3.2.2.8	IC data file		X
3.2.2.9	CPF		X
3.2.2.10	Geolocation table		X
3.2.3	The LPGS shall interface with the Image Assessment System (IAS) to provide Level 1 radiometric characterization data.		X
3.2.4	Requirement deleted by CCR LPGS970006		
3.3	Functional Requirements		
3.3.1	Retrieve L0R Files		

Requirement Number	Requirement Description	Release 1	Release 2
3.3.1.1	The LPGS shall provide the capability to receive L0R data inputs from the ECS. This data shall include the following items:		
3.3.1.1.1	Level 1 image processing request that includes the following:		
3.3.1.1.1a	Selected coordinate reference system for map projection	X	
3.3.1.1.1b	Requested orientation (nominal path or north up)	X	
3.3.1.1.1c	Variable grid cell size selection	X	
3.3.1.1.1d	Output format selection	X	
3.3.1.1.1e	Resampling filter	X	
3.3.1.1.1f	Selected band(s)	X	
3.3.1.1.1g	Selected scene or subinterval identification	X	
3.3.1.1.1h	L1R or L1G image processing selection	X	
3.3.1.1.1i	Geographic area	X	
3.3.1.1.1j	WRS (path/row) scene identifier	X	
3.3.1.1.1k	Internal calibrator (IC) or calibration parameter file (CPF) (default = CPF)	X	
3.3.1.1.2	Data availability notification specifying the location of associated L0R product files ready for transfer	X	
3.3.1.1.3	L0R product files [includes L0R image data, PCD, MSCD and associated calibration files (internal calibrator and calibration parameter files)]	X	
3.3.1.1.4	Requirement deleted by CCR LPGS970007		
3.3.1.1.5	Requirement deleted by CCR LPGS970008		
3.3.1.1.6	Product problem report (trouble ticket)		X
3.3.1.2	The LPGS shall provide the capability to create and send L0R product requests to the ECS.	X	
3.3.1.3	The LPGS shall coordinate resolution of data transfer problems with any L0R product file with ECS.		
3.3.1.3.1	The LPGS shall be able to detect data transfer problems.	X	
3.3.1.3.2	The LPGS shall be able to reorder data.	X	
3.3.2	Generate L1R Digital Images. The LPGS shall be able to extract and process Landsat 7 ETM+ Earth image data from the L0R Earth image data file to produce radiometrically corrected L1R digital images.		
3.3.2.1	The LPGS shall be able to extract and process attitude and ephemeris data from the L0R PCD files.	X	
3.3.2.2	The LPGS shall be able to extract parameters from the L0R internal calibrator or calibration parameter file for use in L1R and L1G processing.	X	
3.3.2.3	The LPGS shall be able to generate gains and biases from either the internal calibrator data or from the calibration parameter file. The default shall be the calibration parameter file.	X	

Requirement Number	Requirement Description	Release 1	Release 2
3.3.2.4	The LPGS shall be able to extract and process mirror scan correction coefficients from the L0R MSCD file to determine scan line quality.	X	
3.3.2.5	The LPGS shall be capable of detecting the following image artifacts:		
3.3.2.5.1	Striping	X	
3.3.2.5.2	Banding	X	
3.3.2.5.3	Requirement deleted by CCR LPGS970012	X	
3.3.2.5.4	Deleted		
3.3.2.5.5	Scan correlated shift	X	
3.3.2.5.6	Saturated detectors **NOTE**: This requirement to be deleted		
3.3.2.5.7	Dropped scan lines	X	
3.3.2.6	The LPGS shall be capable of characterizing the following image artifacts:		
3.3.2.6.1	Striping	X	
3.3.2.6.2	Banding	X	
3.3.2.6.3	Requirement deleted by CCR LPGS970012	X	
3.3.2.6.4	Deleted		
3.3.2.6.5	Deleted		
3.3.2.6.6	Saturated detectors **NOTE**: This requirement to be deleted		
3.3.2.6.7	Dropped scan lines	X	
3.3.2.7	The LPGS shall be capable of applying compensation for the following image artifacts:		
3.3.2.7.1	Striping	X	
3.3.2.7.2	Banding	X	
3.3.2.7.3	Coherent noise	X	
3.3.2.7.4	Memory effect	X	
3.3.2.7.5	Scan correlated shift	X	
3.3.2.7.6	Inoperable detectors	X	
3.3.2.7.7	Saturated detectors **NOTE**: This requirement to be deleted		
3.3.2.7.8	Dropped scan lines	X	
3.3.2.8	The LPGS shall be capable of applying compensation for gain changes within a requested Level 1 scene or subinterval as identified in the Level 0R metadata.	X	
3.3.2.9	The LPGS shall be capable of producing L1R data from L0R data for both the ascending and descending portions of the Landsat 7 orbit.	X	
3.3.2.10	The LPGS shall be able to produce L1R digital images for any combination of the eight spectral channels.	X	

Requirement Number	Requirement Description	Release 1	Release 2
3.3.2.11	The LPGS shall assemble and append to the L1R digital images all of the applicable metadata, quality and accounting data gathered in the construction of the L1R digital image. The complete L1R digital image package contains the following data elements as		
3.3.2.11.1	Level 1R digital image (all requested bands)	X	
3.3.2.11.2	Level 1 metadata file	X	
3.3.2.11.3	Deleted		
3.3.3	Generate L1G Digital Images. The LPGS shall be able to extract and process Landsat 7 ETM+ Earth image data from the L1R Earth image data files to produce systematically corrected L1G digital images.		
3.3.3.1	The LPGS shall have the capability to resample L1R digital images and apply the following map projections:		
3.3.3.1.1	Space Oblique Mercator	X	
3.3.3.1.2	Universal Transverse Mercator (UTM)	X	
3.3.3.1.3	Lambert Conformal Conic	X	
3.3.3.1.4	Transverse Mercator	X	
3.3.3.1.5	Oblique Mercator	X	
3.3.3.1.6	Polyconic	X	
3.3.3.1.7	Polar Stereographic	X	
3.3.3.2	The LPGS shall support the following compensation resampling methods:		
3.3.3.2.1	Nearest neighbor	X	
3.3.3.2.2	Cubic convolution	X	
3.3.3.2.3	Modulation Transfer Function (MTF)	X	
3.3.3.3	The LPGS shall have the capability to produce L1G digital images with the following grid cell characteristics:		
3.3.3.3.1	The grid cell size is variable from 15 M to 60 M in .001 M increments	X	
3.3.3.3.2	The grid cell size is independently variable between spectral bands.	X	
3.3.3.4	The LPGS shall produce L1G digital images that are spatially continuous between contiguous partial subintervals or WRS scenes	X	
3.3.3.5	The LPGS shall have the capability to generate L1G digital images oriented by the following:		
3.3.3.5.1	Nominal path	X	
3.3.3.5.2	North up	X	
3.3.3.6	The LPGS shall be capable of producing L1G data from L0R data for both the ascending and descending portions of the Landsat 7 orbit.	X	
3.3.3.7	The LPGS shall be able to produce L1G digital images for any combination of the eight spectral channels.	X	

Requirement Number	Requirement Description	Release 1	Release 2
3.3.3.8	The LPGS shall assemble and append to the L1G digital images all of the applicable metadata, quality and accounting data gathered in the construction of the L1G digital image. The complete L1G digital image package contains the following data elements as		
3.3.3.8.1	Level 1G digital image (all requested bands)	X	
3.3.3.8.2	Level 1 metadata file	X	
3.3.3.8.3	Deleted		
3.3.4	Generate Level 1 metadata file		
3.3.4.1	The LPGS shall generate ancillary L1R digital image data that describes the contents, processing parameters, and quality indicators of the L1R digital image.	X	
3.3.4.2	The LPGS shall generate ancillary L1G digital image data that describes the contents, processing parameters, and quality indicators of the L1G digital image.	X	
3.3.4.3	Requirement deleted by CCR LPGS970003		
3.3.5	Assess Level 1 digital image quality		
3.3.5.1	The LPGS shall support automatic assessment of Level 1 digital image quality.		X
3.3.5.2	The LPGS shall be able to optionally display any single band of the L1R digital image for visual quality assessment.		X
3.3.5.3	The LPGS shall be able to optionally display any single band of the L1G digital image for visual quality assessment.		X
3.3.5.4	The LPGS shall be able to optionally print a color hard copy of the display of any band(s) of the L1R digital image for visual quality assessment		X
3.3.5.5	The LPGS shall be able to optionally print a color hard copy of the display of any band(s) of the L1G digital image for visual quality assessment.		X
3.3.6	Transfer Level 1 file(s)		
3.3.6.1	The LPGS shall be able to output Level 1 digital images in the following formats:		
3.3.6.1.1	HDF-EOS (L1R and L1G)	X	
3.3.6.1.2	EOSAT FAST (L1G only)		X
3.3.6.1.3	GeoTIFF (L1G only)	X	
3.3.6.2	The LPGS shall transfer L1 files to ECS per the ECS to LPGS ICD.		X
3.3.6.3	The LPGS shall provide the capability to display LPGS Level 1 file transfer summary upon operator request.		X
3.3.6.4	The LPGS shall be able to detect files which have been successfully transferred.		X

Requirement Number	Requirement Description	Release 1	Release 2
3.3.6.5	The LPGS shall be able to mark successfully transferred files as candidates for deletion from LPGS temporary storage.		X
3.3.7	Data Storage		
3.3.7.1	The LPGS shall be able to provide temporary storage for the equivalent of **NOTE**: Wording of this requirement modified by CCR LPGS970009		
3.3.7.1.1	12 L0R WRS scene equivalents for the ingest queue (This requirement added by CCR LPGS970009)		X
3.3.7.1.2	12 L1G WRS scene equivalents for the in process queue (This requirement added by CCR LPGS970009)		X
3.3.7.1.3	12 L1G WRS scene equivalents for the completed queue (This requirement added by CCR LPGS970009)		X
3.3.7.2	The LPGS shall be able retransmit files located in temporary storage.		X
3.3.7.3	The LPGS shall be able to store Level 1 processing information online for 90 days.		X
3.3.7.4	The LPGS shall be able to transfer Level 1 processing information to offline storage after 90 days.		X
3.3.7.5	The LPGS shall be able to recover, display, and print Level 1 processing information located on offline storage for the life of the mission.		X
3.3.8	Control LPGS Operations		
3.3.8.1	The LPGS shall allow the operator to select thresholds for statistics and errors reported by the LPGS.		X
3.3.8.2	The LPGS shall automatically generate messages and alarms to alert the operator of LPGS results and errors exceeding operator-selected thresholds.		X
3.3.8.3	The LPGS shall generate intermediate processing summaries on a periodic basis according to operator specification.		X
3.3.8.4	The LPGS shall provide an option to display Level 1 digital image quality status and statistics at operator request.		X
3.3.8.5	The LPGS shall provide an option to print Level 1 digital image quality status and statistics at operator request.		X
3.3.8.6	The LPGS shall provide the capability to manually override the LPGS automated processing functions.		X
3.3.8.7	The LPGS shall provide the manual capability to cancel Level 1 processing prior to completion of digital image generation.		X
3.3.8.8	The LPGS shall be able to display and print trouble tickets received from ECS.		X

Requirement Number	Requirement Description	Release 1	Release 2
4	LPGS Performance Requirements		
4.1	Performance Requirements		
4.1.1	The LPGS shall be capable of processing a volume of data equivalent to 28 (accounts for 10 percent LPGS internal reprocessing) standard L0R WRS scenes to Level 1 digital images each day.		X
4.1.2	The LPGS shall contribute no greater than 0.7 percent uncertainty to absolute radiometric accuracy during the generation of L1R and L1G digital images.		X
4.1.3	The LPGS shall contribute circular errors no greater than 1.8 m, 1 sigma, in the production of systematically corrected L1G digital images.		X
4.1.4	The LPGS shall provide at least 110 percent of the processing throughput capability required to satisfy the worst case processor loading.		X
4.1.5	The LPGS shall provide at least 125 percent of the random access memory capacity required to satisfy the worst case memory loading.		X
4.1.6	The LPGS shall provide at least 125 percent of the peripheral storage capacity required to satisfy the worst case peripheral storage loading.		X
4.1.7	Deleted		
4.1.8	The LPGS shall produce Level 1G products that are accurate to within 250 meters cross track and 250 meters along track using geometric calibration information generated by IAS and contained in the associated calibration parameter file.		X
4.1.9	The LPGS shall register pixels from one spectral band to the corresponding pixels of another spectral band from the same WRS scene or partial subinterval to an accuracy of 0.28 sensor ground sampling distance (GSD), 90 percent in along-track and cross-track directions provided all inputs are within specifications. The accuracy is relative to the largest sensor GSD of the registered bands. (This requirement added by CCR LPGS970010).	X	
4.2	External Interface Performance Requirements		
4.2.1	The LPGS shall be able to ingest from ECS a data volume equivalent to three WRS scenes worth of standard L0R data for each Level 1 digital image request.	X	
4.2.2	The LPGS shall have the capability to support the transfer to ECS of the equivalent of a minimum of 25 WRS sized Level 1 digital images per day.		X
4.2.3	The LPGS-ECS interface shall provide the capability to transfer to the ECS at least 31 GB of Level 1 output files per day.		X

Requirement Number	Requirement Description	Release 1	Release 2
4.3	Reliability, Maintainability, and Availability		
4.3.1	The LPGS shall provide an operational availability of 0.96 (TBR).		X
4.3.2	The LPGS shall support a mean time to restore (MTTR) capability of 4 hours (TBR).		X
4.4	Security		
4.4.1	The LPGS shall provide system, network, and operations security according to the ESDIS security policy (Reference 7) and the NASA AIS Handbook (Reference 8).		X

Appendix B. Development Area Lines of Code Estimates

Table B-1 reflects the LOC estimate for each LPGS release. Table B-2 reflects the new and re-use estimates for each release. LPGS re-uses code from the IAS, Data Distribution Facility (DDF), and the LPS.

Table B-1. LPGS Lines of Code Estimate by Release

Subsystem	Est LOC	R1	R2
User interface (UI)	5300	2000	3300
Process control subsystem (PCS)	3505	3155	350
Data management subsystem (DMS)	16770	13215	3555
Quality assessment subsystem (QAS)	1600	800	800
Anomaly analysis subsystem (AAS)	2600	1400	1200
Radiometric processing subsystem (RPS)	25850	25850	-
Geometric processing subsystem (GPS)	38940	38940	-
Globals	4400	4300	100
Database	3050	2850	200
Diagnostic and test	3500	2900	600
Grand total	105515	95410	10105

Table B-2. Estimated Reuse per Release

Subsystem	R1		R2	
	New	Reuse	New	Reuse
User interface (UI)	2000	-	3300	-
Process control subsystem (PCS)	2205	950	350	-
Data management subsystem (DMS)	5675	7540	3555	-
Quality assessment subsystem (QAS)	800	-	800	-
Anomaly analysis subsystem (AAS)	1400	-	1200	-
Radiometric processing subsystem (RPS)*	-	25850	-	-
Geometric processing subsystem (GPS)*	-	38940	-	-
Globals	1075	3225	100	-
Database	2550	300	200	-
Diagnostic and test	900	2000	600	-
Total	16605	78805	10105	-
Total per release	95410		10105	
Grand total	105515			

* RPS and GPS are black boxes to LPGS. Software development only has to integrate the subsystems into LPGS.

Appendix C. Mapping of LPGS Tasks and Modules to Releases

This appendix presents the mapping of LPGS tasks and modules to releases. In general, the mapping for LPGS infrastructure subsystems is done at the task level. The mapping for the radiometric and geometric subsystems is done at the module or algorithm level.

Table C-1. Mapping of PCS Tasks to Releases

Task Name	R1	R2
LPGS System Initialization/Termination (PSI)	100%	
Work Order Controller (PWC)	50%	50%
Work Order Generator (PWG)	100%	
Work Order Scheduler (PWS)	50%	50%

Table C-2. Mapping of DMS Tasks to Releases

Task Name	R1	R2
Acquire Data (DAD)	100%	
DAN Manager (DDM)	100%	
Format Level 1 Product (DFL)	70%	30%
Generate Reports (DGR)		100%
Interface with ECS (DIE)	100%	
Ingest L0R Product (DIP)	100%	
Process L0R Product (DPL)	100%	
Resource Manager (DRM)		100%
User interface for ingesting L0R product from tape (DUI)		100%
Transmit (i.e., xmit) Level 1 Product to ECS (DXL)		100%

Table C-3. Mapping of RPS Modules to Releases

Module Name	R1	R2
r0r_Main	100%	
r0r_CharCalData	100%	
r0r_CharDropLines	100%	
r0r_CharImplseNoise	100%	
r0r_CharDetectorSaturation	100%	
r0r_CharScanCorrShift	100%	
r0r_CharSceneData	100%	
r0r_HistogramAnalysis	100%	
r0r_CorrCalSceneData	100%	
r0r_CorrectScanCorrShift	100%	
r0r_CharCoherentNoise	100%	
r0r_CorrectCoherentNoise	100%	
r0r_CharMemoryEffect	100%	
r0r_CorrectMemoryEffect	100%	
r0c_Main	100%	
r0c_CharICData	100%	
r0c_CharRandomNoise	100%	
r0c_CharDetInoperability	100%	
r0c_ProcessICReflective	100%	
r0c_ProcessICEmissive	100%	
r0c_CharSceneData	100%	
r0c_ProcessFASC	100%	
r0c_ProcessPASC	100%	
r0c_CharRelativeRadiometry	100%	
r0c_GenCorrectedGains	100%	
r0c_CorrectImageData	100%	
r1r_Main	100%	
r1r_Corrections	100%	
r1r_Banding	100%	
r1r_Striping	100%	
r1r_CharMTF	100%	
rCR_CRaM	100%	

Table C-4. Mapping of GPS Modules to Releases

Module Name	R1	R2
TMINIT	100%	
TMGRID	100%	
TMRESAMPLE	100%	
MODEL (LIB)	100%	
CORRELATE (LIB)	100%	

Table C-5. Mapping of QAS Tasks to Releases

Task Name	R1	R2
Perform automatic quality assessment of L1G product (Q1G)	100%	
Perform automatic quality assessment of L1R product (Q1R)	100%	

Table C-6. Mapping of UI Screens to Releases

UI Screen Name	R1	R2
Anomaly Analyst User Interface Screens	40%	60%
Production User Interface Screens	40%	60%
Quality Assessment User Interface Screens		100%

Table C-7. Mapping of Other Modules to Releases

Name	R1	R2
Database	90%	10%
Globals	90%	10%
Tools	80%	20%

Abbreviations and Acronyms

AAS	Anomaly Analysis Subsystem
AIT	Algorithm Implementation Team
AUI	analyst user interface
CCR	configuration change request
CNMOS	Consolidated Network and Mission Operations Support
COTS	commercial off-the-shelf
CPF	calibration parameter file
DAAC	Distributed Active Archive Center
DDF	Data Distribution Facility
DHF	Data Handling Facility
DMS	Data Management Subsystem
ECS	EOSDIS Core System
EDC	EROS Data Center
EDC DAAC	EDC Distributed Active Archive Center
EGS	EOS Ground System
ENVI	Environment for Visualizing Images
EOS	Earth Observing System
EOSDIS	Earth Observing System Data and Information System
EROS	Earth Resources Observation System
ESDIS	Earth Science Data and Information System
ETM+	Enhanced Thematic Mapper Plus
FAST	FAST format
FIFO	first in, first out
GB	gigabyte
GeoTIFF	Georeference Tag(ged) Image File Format
GPS	Geometric Processing Subsystem
GSFC	Goddard Space Flight Center

H/STX	Hughes STX
HDF	Hierarchical Data Format
IAS	Image Assessment System
IC	internal calibrator
ICD	interface control document
L0R	Level 0 radiometrically corrected
L1	Level 1
L1G	Level 1 geometrically corrected
L1R	Level 1 radiometrically corrected
Landsat 7	Land Satellite 7
LOC	lines of code
LPGS	Level 1 Product Generation System
LPS	Landsat Processing System
kB	kilobyte
MO&DSD	Mission Operations and Data Systems Directorate
MOSDD	Mission Operations and System Development Division
MSCD	mirror scan correction data
MTF	modulation transfer function
MTTR	mean time to restore
NASA	National Aeronautics and Space Administration
OUI	operator user interface
PCD	payload correction data
PCS	Process Control Subsystem
QAS	Quality Assessment Subsystem
RAID	redundant array of inexpensive disk
RPS	Radiometric Processing Subsystem
TBD	to be determined
TBR	to be resolved
TBS	to be supplied

UI	user interface
UTM	Universal Transverse Mercator
WRS	Worldwide Reference System